U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF CHEMISTRY—BULLETIN No. 103.

H. W. WILEY, Chief of Bureau.

EXPERIMENTAL WORK

IN THE

PRODUCTION OF TABLE SIRUP AT WAYCROSS, GA., 1905,

TOGETHER WITH

A SUMMARY OF THE FOUR-YEAR EXPERIMENT ON FERTILIZATION OF SUGAR CANE.

BY

H. W. WILEY,
Chief of the Bureau of Chemistry,

WITH THE COLLABORATION OF W. B. RODDENBERY, G. R. YOUMANS, AND
ARTHUR GIVEN, OF THE BUREAU OF CHEMISTRY.

WASHINGTON:
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Chemistry,
Washington, D. C., August 3, 1906.

Sir: I have the honor to submit for your inspection and approval a manuscript containing the results of the investigation made by your direction, under authority of Congress during the year 1905, on the production of table sirup from sugar cane in Georgia. There is also appended a brief summary of the experiments on the fertilization of sugar cane which have extended over four years and the conclusions drawn therefrom, the details of which have been previously reported in Bulletins Nos. 70, 75, and 93 of the Bureau of Chemistry. I recommend that this manuscript be published as Bulletin No. 103 of this Bureau.

Respectfully, H. W. Wiley,
Chief.

Hon. James Wilson,
Secretary of Agriculture.

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EXPERIMENTAL WORK IN THE PRODUCTION OF TABLE SIRUP AT WAYCROSS, GA., 1905,

TOGETHER WITH A SUMMARY OF THE FOUR-YEAR EXPERIMENT ON FERTILIZATION OF SUGAR CANE.

INTRODUCTION.

An appropriation of $3,000 was given to the Bureau of Chemistry for the special purpose of further studying the possibilities of the commercial manufacture of table sirup from sugar cane at Waycross, Ga., supplementary to the experimental work of 1902, 1903, and 1904.[a]

From the previous work the following conclusions had been drawn:

> First. A table sirup of high palatability and agreeable color can be made from sugar cane without the addition of any bleaching or clarifying substances of any kind and without any other manipulation than the application of heat, mechanical skimming, settling, and filtering.
>
> Second. A sirup made in this way can be kept indefinitely in barrels, if the barrels be previously sterilized before filling. The sirup is put into the barrels hot as it comes from the filtrations, and the barrels are closed with sterilized stoppers.
>
> Third. By means of a faucet, such as that devised by the Agricultural Experiment Station of Louisiana (Bulletin 75, second series, Agricultural Experiment Station of Louisiana, 1903, pages 256 and following), the contents of a sterilized barrel as described above can be drawn off, from time to time, in any desired amount and the empty space filled with sterilized air in such a way that no danger of fermentation is incurred.

The above points are matters of primary importance from an economical point of view, since they show that a sirup of this kind can be made without the addition of any chemicals of any description, and thus no substance injurious to health is introduced into the sirup. In the second place, it is demonstrated that a sirup made in this way may be safely kept without danger of fermentation until sold and used. By the application of the system of establishing grades of color (described in Bulletin 93), it is possible to offer to the trade sirups of standard color which can be guaranteed absolutely pure and of the highest nutritive and condimental properties.

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[a] U. S. Dept. Agr., Bureau of Chemistry, Buls. Nos. 70, 75, and 93.

It seems that the way has been opened by this experimental work for the gradual expansion of the industry which promises to be of immense value to southern agriculturists and of the highest utility to the consumers generally throughout the country. The people of the United States perhaps more than those of any other country use table sirups, and especially with hot cakes which are so popular as a breakfast dish in all parts of the United States. When such cakes are made of the same wholesomeness as the sirups just described the result is one of the most nutritious and palatable forms of hot cereals, and it seems only reasonable to suppose that such food will rapidly increase in popular favor.

Experience has shown that a sirup made from sugar cane can be consumed regularly for a longer period of time than any other ordinary sirup. Maple sirup, for instance, though eagerly consumed at first, soon begins to pall upon the appetite. To a less degree the same is true of the mixed sirups that are made from glucose and other materials, this being the form of sirup most constantly used.

The object of the final experiments was largely to confirm the observations previously made, and to call special attention to the excellent quality of the product which had been developed, and thus stimulate the production and consumption of larger quantities thereof.

As in previous years the work was conducted along three lines:

(1) Field work consisting of fertilizer experiments for the purpose of developing a better and more abundant supply of cane.

(2) The factory work to establish more uniformly the general principles which underlie the economical manufacture of the product.

(3) The chemical control of the process, including analytical examination of the raw materials and the finished products.

AGRICULTURAL EXPERIMENT, CAIRO, GA., 1905.

SCHEME OF FERTILIZATION.

The experimental work in the field, as in previous years, was conducted by Mr. W. B. Roddenbery, special agent of the Department, at Cairo, Ga.

The same scheme of fertilization was applied to two fields, A and B. Field A is a good grade of pine land which has been in cultivation twenty years or more. It was planted in watermelons in 1904, and the cane was planted on March 21, 1905. Field B is the same grade of pine land but fresher, having been under cultivation about six years. The cane was planted on March 23, and was cut December 7 to 11. There were 63 plats in each field, each plat containing 4 rows 136 feet long, making one-twentieth of an acre to each plat. An unfertilized row was left between the plats.

The fertilizers used in the experiment were made up according to the following formulas, established in the work of previous years:

Normal formula for one ton of fertilizer; normal ration 1,200 pounds per acre.

Ingredients.	Pounds per ton.	Pounds per acre.
Acid phosphate (14 per cent phosphoric acid, P_2O_5)	1,200	720
Upland cotton-seed meal (8 per cent ammonia, NH_3)	400	240
Nitrate of soda (19 per cent ammonia, NH_3)	200	120
Muriate of potash (50 per cent potash, K_2O)	200	120

Revised formula for one ton of fertilizer; normal ration 1,200 pounds per acre.

Ingredients.	Pounds per ton.	Pounds per acre.
Acid phosphate (14 per cent phosphoric acid, P_2O_5)	1,400	840
Upland cotton-seed meal (8 per cent ammonia, NH_3)	300	180
Nitrate of soda (19 per cent ammonia, NH_3)	100	60
Muriate of potash (50 per cent potash, K_2O)	200	120

RESULTS OF FERTILIZER EXPERIMENTS.

The fertilizers were applied, as shown in Tables 1 and 2, to both fields A and B.

TABLE I.—*Results of fertilizer experiment with sugar cane, Cairo, Ga., 1905.*

Plat No.	Amount of fertilizer and method of application.	Yield per acre.		Sucrose.		Reducing sugar.		Purity.	
		Field A.	Field B.	Field A.	Field B.	Field A.	Field B.	Field A.	Field B.
		Tons.	*Tons.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		
1	No fertilizer	7.60	13.40	14.31	14.46	0.62	0.76	92.9	92.3
17	.....do	13.40	17.80	14.11	14.48	.83	.92	93.3	90.0
23	.....do	10.60	13.50	14.79	15.16	.76	.55	92.5	93.8
42	.....do	11.50	14.90	13.95	14.69	.74	.53	91.5	95.6
63	.....do	12.25	13.00	13.85	15.18	.65	.60	93.2	95.3
	Average	11.07	14.52	14.20	14.79	.72	.67	92.6	93.4
2	800 pounds normal formula; 1 application	12.90	19.45	14.34	14.44	.70	.77	93.0	94.5
31	.....do	19.55	16.00	14.30	15.15	.73	.68	92.2	94.2
6	800 pounds normal formula; 2 applications	16.95	22.10	15.21	15.51	.84	.52	93.8	95.0
27	.....do	20.75	17.50	13.86	14.99	.76	.72	89.1	92.6
10	800 pounds normal formula; 3 applications	17.75	22.50	14.54	13.93	.69	.73	93.0	91.4
	Average	17.58	19.51	14.45	14.80	.74	.68	92.2	93.5
3	1,200 pounds normal formula; 1 application	16.95	20.80	14.53	14.00	.66	.93	92.3	92.1
7	1,200 pounds normal formula; 2 applications	19.55	25.30	15.13	14.62	.89	.81	92.6	91.8
28	.....do	23.50	22.55	14.38	15.28	.71	.43	91.1	95.3
11	1,200 pounds normal formula; 3 applications	19.80	20.45	14.96	15.07	.59	.61	92.6	93.7
32	1,200 pounds normal formula; broadcast	19.00	15.00	14.30	15.43	.86	.43	92.2	94.4
43	.....do	16.80	23.00	13.05	15.89	1.14	.53	86.7	95.6
	Average	19.27	21.18	14.39	15.05	.81	.62	91.3	93.5

TABLE I.—*Results of fertilizer experiment with sugar cane, Cairo, Ga., 1905*—Continued.

Plat No.	Amount of fertilizer and method of application.	Yield per acre.		Sucrose.		Reducing sugar.		Purity.	
		Field A.	Field B.	Field A.	Field B.	Field A.	Field B.	Field A.	Field B.
		Tons.	*Tons.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		
4	2,000 pounds normal formula; 1 application	19.30	22.65	14.32	......	0.86	......	90.0	......
8	2,000 pounds normal formula; 2 applications	24.90	30.00	13.65	12.95	.97	0.98	88.9	85.5
29	....do	26.80	25.50	13.97	14.79	.66	.81	90.9	92.5
12	2,000 pounds normal formula; 3 applications	22.30	25.95	14.50	13.35	.76	1.01	91.7	88.7
33	2,000 pounds normal formula; broadcast	19.55	20.30	13.67	15.08	.99	.64	88.4	96.8
44	....do	21.50	23.40	13.82	14.99	.81	.63	89.6	94.2
	Average	22.39	23.63	13.97	14.23	.83	.81	89.9	91.5
[a] 5	1,200 pounds revised formula; 1 application	17.80	22.30	15.00	13.95	.67	.92	95.5	89.7
[b] 9	....do	21.00	28.15	13.82	13.31	.90	1.10	89.6	86.7
13	....do	18.00	22.05	15.22	14.22	.58	.92	94.3	91.6
45	....do	20.35	20.00	12.74	......	1.16	.64	87.6	......
[c] 24	....do	22.10	19.85	14.40	15.43	.92	.62	90.0	94.9
[d] 46	....do	22.50	23.50	14.55	13.74	.75	.78	92.4	90.7
	Average	20.29	22.64	14.24	14.13	.83	.83	91.6	90.5
14	720 pounds acid phosphate; 1 application	13.70	16.00	14.97	15.02	.56	.64	97.4	95.2
15	120 pounds muriate of potash; 1 application	14.50	17.40	14.70	15.66	.60	.54	92.4	95.5
16	240 pounds nitrate of soda; 1 application	17.40	18.90	14.88	14.50	.99	.73	97.4	91.7
18	No potash; 720 pounds acid phosphate; 240 pounds nitrate of soda; 1 application	17.30	21.45	14.90	14.53	.78	.69	97.4	91.7
19	No ammonia; 720 pounds acid phosphate; 120 pounds muriate of potash; 1 application	16.30	19.25	15.25	15.11	.64	.55	93.8	94.2
20	No phosphate; 120 pounds muriate of potash; 240 pounds nitrate of soda; 1 application	15.10	20.30	13.33	13.54	......	1.08	79.2	85.4
21	No ammonia; 720 pounds acid phosphate; 480 pounds kainit; 1 application	12.40	16.40	14.57	14.88	.81	.56	93.6	94.7
22	No potash; 720 pounds acid phosphate; 480 pounds cotton-seed meal; 1 application	15.50	16.85	14.16	15.67	.66	.47	93.3	96.9
25	480 pounds kainit	11.25	10.75	13.12	13.68	1.01	1.01	88.5	87.2
26	480 pounds cotton-seed meal	16.00	16.85	14.54	14.61	.64	.74	92.3	91.3
30	1,200 pounds normal formula; 1 application, but soda not applied till July.	17.90	18.00	14.60	15.10	.87	.58	91.8	94.2
49	1,200 pounds normal formula; 1 application, but soda not used till July	18.75	18.90	14.78	15.22	.65	.53	94.2	94.8
34	1,200 pounds normal formula; 2 applications; 3½-foot rows [a]	21.55	27.90	13.42	15.66	.92	.49	89.3	98.1
47	....do	21.50	22.40	13.31	13.88	.81	.79	89.9	91.4
35	1,200 pounds normal formula; 2 applications; 5-foot rows	16.60	17.70	13.41	14.69	.96	.65	89.9	92.4
48	....do	15.75	17.80	14.13	13.53	.73	.92	88.7	86.0
36	Ribbon cane; 1,200 pounds normal formula; 2 applications	17.75	16.40	13.85	14.72	.89	.64	87.3	95.1
37	24 bushels cotton-seed; 720 pounds acid phosphate; 120 pounds muriate of potash; 1 application	20.65	19.80	14.16	14.96	.91	.57	91.6	96.2
38	57 bushels cotton-seed; 720 pounds acid phosphate; 120 pounds muriate of potash; 1 application	24.95	21.45	13.66	13.07	.92	.99	90.1	86.1

[a] In addition, 100 pounds soda in June, and 100 pounds in July.

[b] In addition, 200 pounds of soda in June.

[c] By error put in 4-foot rows.

[d] Added nitrate of soda in July.

TABLE I.—*Results of fertilizer experiment with sugar cane, Cairo, Ga., 1905*—Continued.

Plat No.	Amount of fertilizer and method of application.	Yield per acre.		Sucrose.		Reducing sugar.		Purity.	
		Field A.	Field B.	Field A.	Field B.	Field A.	Field B.	Field A.	Field B.
		Tons.	*Tons.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		
39	Double phosphate (1,440 pounds); 120 pounds muriate of potash; 240 pounds nitrate of soda; 1 application	26.90	21.40	13.35	14.45	1.05	0.86	89.5	93.5
40	Double potash (240 pounds); 720 pounds acid phosphate; 240 pounds nitrate of soda	19.50	19.45	12.95	13.96	1.18	.98	87.8	89.7
41	Double ammonia (480 pounds nitrate of soda); 120 pounds muriate of potash; 720 pounds acid phosphate	19.50	17.80	13.26	14.56	1.04	.77	86.4	94.1
50	720 pounds acid phosphate; 1 application	13.15	14.00	13.36	15.08	.74	.58	90.4	94.2
51	No phosphate; 120 pounds muriate of potash; 240 pounds nitrate of soda; 1 application	18.50	21.50	14.18	14.38	.75	.75	91.6	91.1
52	Double phosphate (1,440 pounds); 120 pounds muriate of potash; 240 pounds nitrate of soda; 1 application	20.70	23.15	13.26	15.00	.97	.62	88.6	95.2
53	180 pounds acid phosphate; 120 pounds muriate of potash; 240 pounds nitrate of soda; 1 application	21.05	16.55	13.98	14.34	.90	.80	89.7	91.6
54	360 pounds acid phosphate; 120 pounds muriate of potash; 240 pounds nitrate of soda; 1 application	18.85	16.90	13.88	13.11	.84	.99	88.5	85.0
55	1,080 pounds acid phosphate; 120 pounds muriate of potash; 240 pounds nitrate of soda; 1 application	19.75	19.75	13.07	14.50	1.15	.81	89.7	91.1
56	30 bushels cotton-seed; 1,000 pounds acid phosphate; 120 pounds muriate of potash; 1 application	21.75	17.50	13.95	14.79	.76	.75	91.5	92.5
57	30 bushels cotton-seed; 1,000 pounds acid phosphate; 120 pounds muriate of potash; 100 pounds nitrate of soda;[b] 1 application	18.80	23.45	13.41	15.18	.97	.55	89.9	95.3
58	180 pounds acid phosphate; 120 pounds muriate of potash; 240 pounds nitrate of soda; 1 application	16.50	18.10	14.22	13.34	.83	.99	88.8	85.2
59	360 pounds acid phosphate; 120 pounds muriate of potash; 240 pounds nitrate of soda; 1 application	16.50	19.75	13.64	13.17	.98	1.15	85.0	87.4
60	1,080 pounds acid phosphate; 120 pounds muriate of potash; 240 pounds nitrate of soda; 1 application	17.00	23.25	13.08	14.77	.89	.59	89.7	91.4
61	30 bushels cotton-seed; 1,000 pounds acid phosphate; 120 pounds muriate of potash; 100 pounds nitrate of soda	21.25	22.00	13.77	14.72	.94	.78	89.6	94.6
62	30 bushels cotton-seed; 1,000 pounds acid phosphate; 120 pounds muriate of potash; 100 pounds nitrate of soda[b]	21.05	22.25	12.48	14.88	1.29	.72	84.5	98.0
	Average	18.16	19.17	13.99	14.52	.87	.74	90.3	92.2

The figures given in Table II, averaged and arranged to show the effects of varying amounts of fertilizers, will be discussed in connection with the summary of the four-year experiment. It should be noted, however, that the analysis of the samples of juice sent to the Bureau of Chemistry by Mr. Roddenbery on December 29 was not completed until March owing to pressure of other work, and it seems probable that the exceedingly high purities may be to some extent due to loss of liquid from the bottles during the two months storage, although the containers appeared to be tightly stoppered.

In the following table the tonnage results have been arranged and averaged so as to make possible a comparison of the yields obtained with the same amounts of fertilizer and varying methods of application.

TABLE II.—*Yields obtained by varying methods of application of fertilizer, Cairo, Ga., 1905.*

Plat No.	Amount of fertilizer and method of application.	Yield per acre.	
		Field A.	Field B.
		Tons.	*Tons.*
1	No fertilizer	7.60	13.40
17	.....do	13.40	17.80
23	.....do	10.60	13.50
42	.....do	11.50	14.90
63	.....do	12.25	13.00
	Average	11.07	14.52
	One application:		
2	800 pounds normal formula	16.23	17.73
31	800 pounds normal formula		
3	1,200 pounds normal formula	16.95	20.80
4	2,000 pounds normal formula	19.30	22.65
	Average	17.72	20.43
	Two applications:		
6	800 pounds normal formula	16.95	22.10
27	800 pounds normal formula	20.75	17.50
7	1,200 pounds normal formula	19.55	25.30
28	1,200 pounds normal formula	23.50	22.55
8	2,000 pounds normal formula	24.90	30.00
29	2,000 pounds normal formula	26.80	25.50
	Average	22.08	23.83
	Three applications:		
10	800 pounds normal formula	17.75	22.50
11	1,200 pounds normal formula	19.80	20.45
12	2,000 pounds normal formula	22.30	25.95
	Average	19.95	22.96
	One application:		
3	1,200 pounds normal formula	16.95	20.80
4	2,000 pounds normal formula	19.30	22.65
	Average	18.10	21.73
	Two applications:		
7	1,200 pounds normal formula	19.55	25.30
28	1,200 pounds normal formula	23.50	22.55
8	2.000 pounds normal formula	24.90	30.00
29	2,000 pounds normal formula	25.80	25.50
	Average	23.44	25.84
	Three applications:		
11	1,200 pounds normal formula	19.80	20.45
12	2,000 pounds normal formula	22.30	22.95
	Average	21.05	21.70
	Broadcast:		
32	1,200 pounds normal formula	19.00	15.00
33	2,000 pounds normal formula	19.55	20.30
43	1,200 pounds normal formula	16.80	23.00
44	2,000 pounds normal formula	21.50	23.40
	Average	19.21	20.42

FLORIDA CANES.

It is interesting to compare the canes of Georgia with some grown below the frost line in Florida. The figures given in the following table show that in southern Florida, where the canes continue to grow throughout the winter without being frost-bitten, they attain a remarkable degree of sweetness. There is a minimum quantity of reducing sugar present which probably would be indicated as zero by the ordinary volumetric method. It may be considered that the amounts of reducing sugar obtained in the mature cane were in most cases due to the action of the reagents upon the cane sugar. In other words the canes have apparently attained their normal maturity.

The increasing richness of the canes is shown by comparing those harvested in March with those from the same locality analyzed in November. The cane received on November 11 contained 13.50 per cent of sucrose, while the canes from the same locality received on March 31, and cut probably three days previously, contained 20.90 per cent of sucrose. The purity of the juice received on November 21 is 79 per cent, while that of the juice received on March 31 is 91.30 per cent, the richest cane ever analyzed in this Bureau.

Canes of this degree of richness would be of exceptionally fine quality for sugar making, but it would be rather difficult to make a sirup from them which would not crystallize. In other words, the ordinary inversion from evaporation would scarcely be sufficient to prevent crystallization of the finished product.

TABLE III.—*Analyses of Florida canes.*

Serial No.	Description.	Date.	Sucrose.	Reducing sugar.	Purity.
			Per cent.	*Per cent.*	
3800	Red cane, Orange County, Fla	Nov. 21, 1905	13.50	0.30	79.00
	Manatee County, Fla.:[a]				
4022	D 74	Feb. 19, 1906	15.60	.24	87.20
4023	D 95	do	17.65	.26	89.40
4042	Ribbon cane	Mar. 8, 1906	15.00	.14	88.20
4043	D 95	do	16.40	.15	89.60
4051	D 74	Mar. 31, 1906	16.50	.10	86.00
4052	Green or Simpson cane	do	20.90	.22	91.30

[a] Grown by H. L. Abel at Terra Ceia.

TECHNICAL CONTROL OF THE FACTORY.

The operation of the factory was under the control of Mr. G. R. Youmans, special agent, assisted by Mr. Arthur Given, in charge of the chemical work and technical control, and by Mr. O. P. Angelo. The following extracts from the report of Mr. Given, together with the analytical tables showing the quality of the products obtained and the quantity of juice and sirup produced, set forth the main points in the season's work.

IMPROVEMENTS IN THE FACTORY.

The making of the necessary changes and improvements in the experimental sirup factory at Waycross, Ga., for the season of 1905 was begun on October 1. The changes and additions made were as follows:

(1) An additional high-pressure evaporator like the one already in use, except that it has copper coils and stuffing boxes.

(2) Copper coils for the evaporator with stuffing boxes like those on the low-pressure evaporator.

(3) A large steam trap for each of the high-pressure evaporators and for the high-pressure coil of the low-pressure evaporator.

(4) Two of the traps displaced by the changes named above to be used on the clarifiers, giving each clarifier its own trap.

(5) The sewer relaid, using 6-inch pipe from the junction of the two 4-inch lines to the street sewer.

(6) The fire-brick lining of the front of the fire box of the old boiler taken out, relaid, and secured so as to be permanent.

(7) A centrifugal oiler applied to the engine crank, to prevent its heating as it did with the oil cup in use.

(8) A hood built over the feed-water tank, and an opening made in the side of the building to permit the escape of steam from the heated water, so that it would not rise in the mill shed, rusting the shafting and pulleys and making the belts slippery.

(9) The light galvanized-iron pipes leading from the clarifiers to the settling and scum tanks replaced by standard 3-inch galvanized-iron pipes.

(10) Two leaks in the low-pressure evaporator stopped.

(11) A leak in the lining of the same evaporator stopped.

(12) An awning crank, ratchet, and hangers for raising the roof of the ventilator.

(13) The mechanical strainer, materials for which were on hand, put in and connected with both rotary and steam pumps.

(14) The engines and pumps put in order to begin work.

In addition to these changes, which had been recommended at the close of the work of the preceding year, two other improvements were made: (1) The 1½-inch reducing valve on the steam pipe leading from the main steam pipe to the low-pressure receiver was removed and a 2½-inch valve substituted, the remainder of the line being enlarged accordingly; (2) the back pressure valve on the receiver, which had always given trouble, was replaced with a superior valve. Some of the changes recommended in the report of the previous year were not made, as the expense entailed did not seem to be warranted for the conduct of the last year of the experimental work.

The new evaporator was installed on the third floor of the factory, where space had been provided the year before, the only change necessary being the moving of the pipe-room door to the opposite side of the room. The new stuffing boxes and coils were placed in the old high-pressure evaporator and both high-pressure evaporators gave excellent service throughout the season. As the new evaporator was much larger than the old one, it was possible to keep pace with the mills, except when time was lost by the necessity of boiling off the coils, when the old evaporator was called into use. In like manner the small evaporator was used to supplement the low-pressure evaporator under the same conditions, thus saving much time. All the various fittings required for the other work proved entirely satisfactory, and the steam traps for the high-pressure coils removed the condensed water without difficulty under all conditions.

All of the alterations in the factory were completed by November 1, and Mr. Youmans began the grinding of the cane on the morning of November 3.

MANUFACTURING AND ANALYTICAL DATA.

The cane was much like that of former years, both in appearance and in richness. The sirup produced, however, was much more uniform in quality, owing probably to a more careful attention to details in its manufacture along the lines indicated by the experiments of the three preceding years. The sirup was much darker in color than that produced in 1904, and no explanation of the difference was discovered. It was thought that it might be due to the redissolving of a part of the scum, since the filters were not used, but this explanation proved inadequate, as a run with the filters was made and the filtered sirup, while perfectly clear, was no lighter than the unfiltered.

On November 28 the work on the Youmans cane was completed and the factory was operated by Mr. W. J. Smith until December 7, making up about 4 acres of cane into sirup. The analytical work on the juices produced from the Waycross cane was all done at the factory and the results are given in Table IV. The figures in this table for juice and sirup produced from the Youmans cane are averaged by runs; that is, they are divided into periods at the end of which there was no juice or semisirup in process of manufacture; and all the finished sirup was either packed or was measured in the tanks and deducted from the next run. The tons of cane used are calculated from the number of tanks of juice obtained, 1⅛ tons producing one tank of juice on an average, as determined by the experiments of the preceding years. While some of the juice records are known to be exact the fact that there are discrepancies between the amount of sugar in the juice and the total sugars in the sirup produced from it indicates that the grinding record (number of tanks of juice) was in many cases overstated. This explanation is the more probable as this record was of necessity left in the hands of the clarifier man, and this position was filled by three different men during the season.

The record of the amount of sirup produced is accurate and shows an excellent average per ton of cane. If the supposition that the amount of cane used is overstated be correct this average should be still higher. The working of the factory showed uniform improvement over that of the preceding years. With only twenty-five days grinding, 12,240 gallons of sirup were produced from 560 tons of cane, an average of nearly 22 gallons per ton, which is 2.4 gallons per ton more than was obtained in 1904, although the cane of 1905 was slightly less rich than that produced in the preceding year (1905, 11.16 per cent of sucrose; 1904, 11.65 per cent). The daily production averaged 22 gallons of sirup more than was made in 1904. The best 5-day run in 1905 gave 600 gallons of sirup more than the best run of equal length in 1904 and produced the same number of gallons per ton.

ANALYSES OF JUICE FROM WAYCROSS CANE.

The manufacturing and analytical data on the juice and sirup produced from the cane of Mr. Youmans and that of Mr. Smith in the season of 1905 are given in the following table:

TABLE IV.—*Analyses of juice and amount of sirup produced, season of 1905.*

CANE OF G. R. YOUMANS, WAYCROSS, GA.

Serial No.	Date of grinding.	Cane.	Juice.	Density.	Sucrose.	Reducing sugar.	Purity	Sirup.
	1905.	*Tons.*	*Gallons.*	*°Brix.*	*Per cent.*	*Per cent.*		*Gallons.*
3951	Nov. 3	10.13	1,665	14.5	10.8	2.62	74.5	0
3952	Nov. 4	16.87	2,775	15.0	9.9	2.14	66.7	315
3953	Nov. 6	25.88	4,255	15.1	9.5	2.77	62.3	420
3954	Nov. 7	21.37	3,515	15.4	10.9	2.61	70.8	595
3955	Nov. 8	24.75	4,070	15.2	Spoiled before analysis.			350
3956	Nov. 9	27.00	4,440	14.0	Spoiled before analysis.			595
3957	Nov. 10	6.75	1,110	13.7	11.0	2.14	80.3	420
Total		132.75	21,380					2,695
Daily average		18.96	3,119	14.85	10.38	2.53	68.5	385
Sirup per ton of cane								20.31
3958	Nov. 13	27.00	4,440	14.4	9.7	2.48	67.4	350
3959	Nov. 14	25.88	4,255	14.6	10.8	2.16	74.0	350
3960	Nov. 15	23.62	3,885	15.0	11.3	2.24	75.4	735
3961	Nov. 16	23.63	3,885	14.7	11.2	2.86	76.2	350
3962	Nov. 17	27.00	4,440	14.6	10.2	2.42	70.8	525
3963	Nov. 18	15.75	2,595	12.8	8.4	2.50	65.6	660
Total		142.88	23,500					2,970
Daily average		23.81	3,917	14.45	10.33	2.44	71.8	495
Sirup per ton of cane								20.79
3964	Nov. 20	23.62	3,885	15.5	11.7	2.04	75.5	230
3965	Nov. 21	25.88	4,255	15.4	11.7	2.14	76.0	630
3966	Nov. 22	22.50	3,700	15.4	11.5	2.12	74.7	400
3967	Nov. 23	33.75	5,550	15.2	11.3	2.11	74.4	480
3968	Nov. 24	11.25	1,850	14.9	11.5	1.90	77.2	1,050
Total		117.00	19,240					2,790
Daily average		23.40	3,847	15.40	11.59	2.10	75.32	558
Sirup per ton of cane								23.85
3969	Nov. 25	23.62	3,885	14.9	11.0	1.81	73.2	490
Sirup per ton of cane								20.74
3970	Nov. 27	28.13	4,625	14.2	10.2	2.01	71.8	350
3971	Nov. 28	33.75	5,550	14.4	10.4	1.89	72.2	895
Total		68.75	10,175					1,245
Daily average		30.94	5,088	14.31	10.31	1.94	72.0	643
Sirup per ton of cane								20.78
General total		478.13	78,625					10,190
General average		22.77	3,744	14.80	10.72	2.25	72.25	485.2
Average amount of sirup per ton of cane								21.31

Table IV.—*Analyses of juice and amount of sirup produced, season of 1905*—Continued.

CANE OF W. J. SMITH, WAYCROSS, GA.

Serial No.	Date of grinding.	Cane.	Juice.	Density.	Sucrose.	Reducing sugar.	Purity.	Sirup.
	1905.	*Tons.*	*Gallons.*	°*Brix.*	*Per cent.*	*Per cent.*		*Gallons.*
3972	Nov. 29	23.62	3,885	16.8	14.0	1.29	83.3	315
3973	Dec. 1	21.38	3,515	16.7	13.6	1.45	81.4	770
Total		45.00	7,400					1,085
Daily average		22.50	3,700	16.75	13.80	1.37	82.40	543
Sirup per ton of cane								24.13
3974	Dec. 5, 6	21.38	3,515	16.7	13.2	1.89	79.0	200
3975	Dec. 7	15.19	2,497	16.5	15.0	1.83	78.8	765
Total		36.57	6,012					965
Daily average		18.29	3,006	16.61	13.10	1.86	78.9	483
Sirup per ton of cane								26.37
General total		81.57	13,412					2,050
General average for two runs		20.39	3,353	16.69	13.50	1.59	80.84	512.5
Sirup per ton of cane								24.64

RESULTS FOR SEASON—25 DAYS' GRINDING.

Totals		559.69	92,037					12,240
Averages		22.39	3,681	15.07	11.16	2.15	73.63	489.6
Average yield of sirup per ton of cane								21.87

An inspection of the table shows that the average amount of cane ground daily was 22.39 tons. Probably ten hours would be a high average for the length of time the mill was running daily, which makes an hourly average of 2.24 tons. The largest amount of cane ground was on the 23d of November and again on the 28th, when the mill ran the full day, about eleven hours, grinding 33.75 tons.

It is evident that the greatest economy in the operation of a factory of this kind can only be secured when it is run continuously day and night. There is a great expense for fuel and labor attending the closing down of a factory in the evening and bringing it again into action in the morning.

The average quantity of sirup per ton of cane was 21.31 gallons on Mr. Youmans's cane and 24.64 on Mr. Smith's cane, and the average for both for the whole season is 21.87 gallons. The average percentage of total solids in Mr. Youmans's cane for the season is 14.80, the average percentage of sucrose 10.72, the average percentage of reducing sugar 2.25, and the average purity coefficient 72.25.

For Mr. Smith's cane, which was very much richer, the average percentage of total solids is 16.69 per cent, the average percentage of sucrose 13.50, the average percentage of reducing sugar 1.59, and the average purity coefficient 80.84. It appears that the cane furnished by Mr. Smith would be of excellent quality for the manufacture of sugar, and with the use of the best modern methods would yield as much as 220 pounds of sugar per ton.

For the two lots of cane, covering the entire run of twenty-five days, the average percentage of total solids is 15.07 per cent; of sucrose, 11.16; of reducing sugar, 2.15; and the average purity coefficient 73.63.

ANALYSES OF SIRUPS AT EXPERIMENTAL FACTORY, WAYCROSS, GA.

SEMISIRUPS.

The average composition of the semisirups as shown in Table V gives a general indication of the degree of concentration. The lowest percentage of total solids is found in No. 4003, namely, 38.4 per cent, and the highest in No. 4009, namely, 55.5 per cent. The total solids in all of the semisirups analyzed average 48.2 per cent.

The lowest sucrose in the semisirups occurs in No. 4003, 30.19 per cent, and the highest in No. 4008, 46.56 per cent, the average amount of sucrose being 38.37 per cent.

The smallest amount of reducing sugar in any of these samples is found in No. 4008, namely, 5.06 per cent, and the largest amount in No. 4007, namely, 10.17 per cent. The average amount of reducing sugar present is 7.74 per cent. The percentage of inversion [a] is greatest in sample No. 4007, 9.30 per cent, and least in No. 4011, namely, 1.09 per cent.

The semisirups were not all subjected to analysis, but the figures given in the table show the general character of these products. It is evident, by comparison with the figures given for the juices and the completed sirups, that nearly all of the changes effected take place during the conversion of the semisirups into sirups, there being comparatively little difference between the composition of the juice and of the semisirup.

Table V.—*Analyses of semisirups at the experimental sirup factory, Waycross, Ga., 1905.*

Serial No.	Date.	Density.	Sucrose.	Reducing sugar.	Inversion.	Total sugar in total solids.
	1905.	*° Brix.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
4001	Nov. 21	43. 4	33. 87	7. 92	3. 96	96. 29
4002	Nov. 22	45. 7	35. 70	8. 15	3. 44	95. 95
4003	Nov. 23	38. 4	30. 19	7. 10	3. 76	97. 11
4004	Nov. 24	48. 3	36. 47	9. 38	7. 49	94. 93
4005	Nov. 25	49. 0	39. 02	7. 34	1. 91	94. 61
4006	Nov. 27	51. 4	39. 65	9. 07	2. 48	94. 79
4007	Nov. 28	46. 4	32. 99	10. 17	9. 30	95. 02
4008	Nov. 29	52. 8	46. 56	5. 06	1. 22	97. 77
4009	Dec. 1	55. 5	45. 21	8. 94	7. 29	97. 57
4010	Dec. 6	50. 0	40. 68	6. 63	1. 63	94. 62
4011	Dec. 7	49. 8	41. 69	6. 41	1. 09	96. 20
Average		48. 2	38. 37	7. 74	3. 95	95. 89

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[a] U. S. Dept. Agr., Bureau of Chemistry, Bul. 93, p. 66, formula for calculating percentage of inversion.

Table VI.—*Analyses of sugar-cane sirups at experimental sirup factory, Waycross, Ga., 1905.*

Serial No.	Color.	Appearance.	Date of manufacture.	Density.	Sucrose.	Reducing sugar.	Inversion.	Total sugar in total solids.
			1905.	°*Brix.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
3977	16	Bright, many fine particles	Nov. 4	76.8	45.20	27.47	22.75	93.32
3978	16	Bright, fewer particles	Nov. 6	75.7	38.77	34.34	30.65	96.58
3979	15	do	Nov. 7	75.7	43.36	29.14	25.08	95.77
3980	15	Bright, full of particles	Nov. 8	76.8	43.54	28.28	....	93 52
3981	14	do	Nov. 9	75.7	42.59	27.09	....	92.05
3982	16	Bright, almost clear	Nov. 10	75.5	39.73	31.02	31.98	93.71
3983	14	do	Nov. 13	75.7	49.75	22.61	13.20	95.59
3984	14	Bright, full of particles	Nov. 14	76.2	48.77	24.34	18.35	95.95
3985	13	Fairly bright, full of specks	Nov. 15	76.2	49.38	24.04	18.72	96.35
[a] 3986	17	do	Nov. 16	76.8	41.23	31.53	28.04	94.74
3987	16	do	Nov. 17	76.8	46.28	24.34	18.30	91.95
3988	16	do	Nov. 18	76.8	45.15	23.89	14.64	90.00
3989	16	Fewer particles	Nov. 20	75.6	48.70	19.53	15.59	90.22
[b] 3990	16	Bright and clear, few specks	Nov. 21	76.2	47.17	23.45	20.29	92.68
[b] 3991	16	do	Nov. 22	75.1	46.28	22.10	19.16	91.05
[b] 3992	14	Bright, full of specks	Nov. 23	76.2	43 28	27.47	26.54	92.85
[b] 3993	15	Bright and quite clear, a few	Nov. 24	75.7	44.29	25.64	25.66	92.38
[b] 3994	15	Bright, full of specks	Nov. 25	75.1	49.24	19.23	15.65	91.30
[c] 3995	16	Absolutely bright and clear	Nov. 27	75.7	48.82	18.85	13.15	89.39
[b] 3996	11	Fairly bright, fairly clear	Nov. 28	75.1	45.45	23.17	21.00	91.37
[b] 3997	13	Fairly bright, full of specks	Nov. 29	74.5	53.76	16.72	16.05	94.60
[b] 3998	11	Muddy, full of specks	Dec. 1	73.4	49.60	18.48	18.66	92.75
[b] 3999	13	Bright and clear, some specks	Dec. 6	75.7	46.40	23.74	23.56	92.66
[b] 4000	12	Bright, full of specks	Dec. 7	74.6	48.55	21.37	20.05	93.86
		Average	....	75.73	46.05	24.49	21.69	93.11

[a] Slightly scorched.

[b] Semisirup strained through double cheese cloth.

[c] Semisirup filtered in a sand filter; see Bul. 93, p. 51.

FINISHED SIRUPS.

Table VI, showing the composition of the finished sirups, is of great interest. The density of the finished sirups, is quite uniform, the smallest percentage of total solids being found in No. 3998, namely, 73.4 per cent, and the highest amount being found in Nos. 3977, 3980, 3986, 3987, and 3988, namely, 76.8 per cent. The average total solids in the finished sirups is 75.73 per cent, showing an average water content of 24.27 per cent.

The smallest quantity of sucrose in the finished sirups is found in No. 3978, namely, 38.77 per cent, and the highest quantity in No. 3997, namely, 53.76 per cent. The average amount of sucrose in the finished sirups is 46.05 per cent. The smallest quantity of reducing sugar is found in No. 3997, namely, 16.72 per cent, and the highest in No. 3978, namely, 34.34 per cent. The average percentage of reducing sugar is 24.49 per cent. The percentage of inversion, calculated accordingly to the formula given in Bulletin 93, is smallest in No. 3995, namely, 13.15 per cent, and the highest in No. 3982, namely, 31.98 per cent. In two instances the percentage of inversion was not calculated.

The ratio of the total sugar to the total solids shows a comparative freedom of the finished sirups from soluble products other than sugar. The smallest ratio of total sugar to total solids is found in the case of

No. 3995, namely, 89.39 per cent, and the highest is found in No. 3978, namely, 96.58 per cent. This sample therefore may be considered as being more nearly pure sugar and water than any other of the samples produced.

SUMMARY OF FOUR-YEAR EXPERIMENT IN FERTILIZATION OF SUGAR CANE, 1902–1905.

EXPERIMENTAL FIELDS.

The experimental work on this subject having been concluded, it is desirable to compare the data for the four years in order to get a view of the general effect of the different methods of fertilization upon the yield of cane and upon its relative content of sucrose and reducing sugar. The two fields on which the experimental cultures were made are designated as A and B. The fields marked A and B, however, were not the same pieces of land, except for the years 1902 and 1905. The fields marked A and B for 1903 and 1904 were different pieces of land. Therefore no direct comparison can be made between fields A and B for the whole period, but only for the years 1902 and 1905.

Field A, for 1902 and 1905, is an old field continuously in cultivation for twenty years, of a sandy soil, containing very little plant food other than that supplied by the fertilizers. Field B is a land of similar composition, but only in cultivation six years, and therefore contains considerably larger proportions of plant food than the older field.

THE FERTILIZERS USED.

Before beginning the comparisons it is well to submit a table showing the average composition of the fertilizers used during the time of the experiment. This table contains the average composition of the fertilizers by direct analysis for the years 1903 and 1904. A direct analysis of the fertilizers used in 1905 was not made, but as the fertilizers were of similar character they do not differ materially from the average of the three years, which is contained in the following table:

TABLE VII.—*Average analysis of fertilizers used in experimental work in 1902–1904.*

Fertilizer.	Phosphoric acid (P_2O_5).			Potash (K_2O).	Nitrogen as ammonia (NH_3).
	Total.	Available.	Insoluble.		
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Acid phosphate	16.43	15.88	0.55		
Cotton seed	1.11			0.81	3.36
Cotton-seed meal	2.38	1.83	.55	2.06	7.47
Kainit				11.94	
Muriate of potash				50.54	
Nitrate of soda					18.08
Normal formula		9.03		5.15	3.90

THE RESULTS SECURED.

Having ascertained from the foregoing table the character of the fertilizers used, we now proceed to compare the results of the four years' work by bringing into tabular form the data obtained in the analytical and field work for the whole period. These data are arranged by bringing together into one expression all similar data for the four years wherever direct comparison was possible, and for shorter periods of time where no direct comparisons were possible during the whole period. The average yield for 1902 and 1905 immediately follows that for the whole period of the experiment.

Table VIII.—*Comparative statement of yield of cane lands with different fertilizers, and quality of cane produced, Cairo, Ga., 1902–1905.*

Year.	Plat No.	Yield per acre.		Sucrose.		Reducing sugar.	
		Field A.	Field B.	Field A.	Field B.	Field A.	Field B.
		NO FERTILIZER.					
		Tons.	*Tons.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1902	24	9.12	12.00	15.72	14.17	0.44	1.21
1903	1	4.75	2.30	8.40	7.00	1.45	1.34
	5	7.15	4.35	8.40	9.60	1.92	1.82
	9	5.25	3.05	9.50	7.00	1.90	1.34
	13	2.90	2.95	7.90	7.90	1.70	1.58
	17	11.35	3.15	10.30	9.50	1.92	1.40
	23	7.75	2.25	10.60	6.20	1.42	1.47
	30	1.30	3.15	7.90	7.00	1.70	1.34
	42	3.25	2.85	7.90	7.00	1.70	1.34
Average	......	5.46	3.01	8.86	7.65	1.71	1.45
1904	1	12.40	4.60	14.38	12.36	1.08	1.53
	17	17.45	2.50	12.98	12.98	1.28	1.75
	23	15.15	6.90	14.31	11.47	1.00	1.33
	42	18.30	3.55	14.61	12.43	1.05	1.78
Average	......	15.83	4.39	14.07	12.31	1.10	1.60
1905	1	7.60	13.40	14.31	14.46	.62	.76
	17	13.40	17.80	14.11	14.48	.83	.92
	23	10.60	13.50	14.79	15.16	.76	.55
	42	11.50	14.90	13.95	14.69	.74	.53
	63	12.25	13.00	13.85	15.18	.65	.60
Average	......	11.07	14.52	14.20	14.79	.72	.67
General average	......	9.53	7.01	11.88	11.03	1.23	1.26
Average, 1902 and 1905	......	10.75	14.10	14.46	14.69	.67	.76
		800 POUNDS NORMAL FORMULA; BROADCAST.					
1903	31	7.20	7.95	9.80	10.60	1.58	1.30
		800 POUNDS NORMAL FORMULA; 1 APPLICATION.					
1902	9	16.88	25.76	15.03	14.09	0.53	1.04
1903	2	11.15	14.27	10.60	11.00	1.41	1.57
1904	2	24.75	14.30	15.18	14.45	.85	.82
	31	23.20	15.55	14.76	13.82	1.02	1.16
1905	2	12.90	19.45	14.34	14.44	.70	.77
	31	19.55	16.00	14.30	15.15	.73	.68
General average	......	18.07	17.56	14.04	13.83	.87	1.01
Average, 1902 and 1905	......	16.44	20.40	14.56	14.56	.65	.83

TABLE VIII.—*Comparative statement of yield of cane lands with different fertilizers, and quality of cane produced, Cairo, Ga., 1902–1905*—Continued.

Year.	Plat No.	Yield per acre.		Sucrose.		Reducing sugar.	
		Field A.	Field B.	Field A.	Field B.	Field A.	Field B.
		Tons.	*Tons.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
800 POUNDS NORMAL FORMULA; 2 APPLICATIONS.							
1902	10	21.48	28.32	15.58	14.68	0.44	0.92
1903	6	13.45	10.55	9.20	10.00	2.00	1.58
	27	17.25	10.65	10.20	10.05	1.69	1.28
1904	6	20.35	11.45	14.86	15.06	.94	.96
	27	20.25	18.65	14.24	14.58	1.20	1.29
1905	6	16.95	22.10	15.21	15.51	.84	.52
	27	20.75	17.50	13.86	14.99	.76	.72
General average		18.64	17.03	13.31	13.55	1.12	1.04
Average, 1902 and 1905		19.73	22.64	14.88	15.06	.68	.72
800 POUNDS NORMAL FORMULA; 3 APPLICATIONS.							
1903	10	10.05	9.50	10.90	9.10	1.79	1.48
1904	10	19.05	17.50	15.16	14.08	.87	1.02
1905	10	17.75	22.50	14.54	13.93	.69	.73
Average		15.62	16.50	13.53	12.37	1.12	1.07
1,200 POUNDS NORMAL FORMULA; BROADCAST.							
1902	1	19.96	26.88	16.22	14.97	0.40	0.80
1903	32	12.10	9.05	10.60	10.80	1.40	1.69
1905	32	19.00	15.00	14.30	15.43	.86	.43
	43	16.80	23.00	13.05	15.89	1.14	.53
General average		16.97	18.48	13.54	14.27	.95	.86
Average, 1902 and 1905		18.59	21.63	14.52	15.43	.80	.59
1,200 POUNDS NORMAL FORMULA; 1 APPLICATION.							
1902	2	20.56	27.64	15.51	15.10	0.51	0.89
1903	3	11.95	14.32	10.10	....	1.53	....
1904	3	28.00	17.50	14.76	14.32	.95	1.20
	32	27.90	18.95	14.33	14.08	1.09	1.28
	30	26.55	21.70	13.85	13.88	1.23	1.28
1905	3	16.95	20.80	14.53	14.00	.66	.93
	30	17.90	18.00	14.60	15.10	.87	.58
	49	18.75	18.90	14.78	15.22	.65	.53
General average		21.07	19.73	14.06	14.53	.94	.96
Average, 1902 and 1905		18.54	21.34	14.86	14.86	.67	.74
1,200 POUNDS NORMAL FORMULA; 2 APPLICATIONS.							
1902	3	20.36	28.72	15.66	15.56	0.44	0.71
1903	7	13.30	16.15	9.80	10.70	1.92	1.58
	28	13.50	13.60	10.20	10.60	1.66	1.48
	34	12.75	11.00	11.40	10.60	1.24	1.40
	35	10.60	11.40	10.80	11.10	1.60	1.58
1904	7	22.90	18.60	15.03	14.89	.94	1.13
	28	26.05	20.80	15.11	13.53	1.00	1.50
	34	27.10	21.00	13.16	15.43	1.51	1.66
	35	23.70	15.15	13.32	....	1.42	....
	36	25.60	....	13.19	14.34	1.49	1.53
1905	7	19.55	25.30	15.13	14.62	.89	.81
	28	23.50	22.55	14.38	15.28	.71	.43
	34	21.55	27.90	13.42	15.66	.92	.49
	35	16.60	17.70	13.41	14.69	.96	.65
	36	17.75	16.40	13.85	14.72	.89	.64
	47	21.50	22.40	13.31	13.88	.81	.79
	48	15.75	17.80	14.13	13.53	.73	.92
General average		19.53	19.15	13.25	13.70	1.13	1.08
Average, 1902 and 1905		19.57	22.35	14.16	14.78	.79	.68

Table VIII.—*Comparative statement of yield of cane lands with different fertilizers, and quality of cane produced, Cairo, Ga., 1902–1905*—Continued.

Year.	Plat No.	Yield per acre.		Sucrose.		Reducing sugar.	
		Field A.	Field B.	Field A.	Field B.	Field A.	Field B.
1,200 POUNDS NORMAL FORMULA; 3 APPLICATIONS.							
		Tons.	*Tons.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1902	4	19.60	28.00	15.76	13.90	0.39	1.18
1903	11	11.55	11.50	9.16	10.00	2.06	1.58
1904	11	23.45	20.40	13.22	13.71	1.42	1.54
1905	11	19.80	20.45	14.96	15.07	.59	.61
General average	......	18.60	20.08	13.28	13.17	1.12	1.23
Average, 1902 and 1905	......	19.70	24.23	15.36	14.49	.49	1.21
2,000 POUNDS NORMAL FORMULA; BROADCAST.							
1902	5	23.24	35.36	16.04	13.36	0.75	1.18
1903	33	15.30	13.40	10.80	10.80	1.52	1.32
1905	33	19.55	20.30	13.67	15.08	.99	.64
	44	21.50	23.40	13.82	14.99	.81	.63
General average	......	19.90	23.12	13.58	13.56	1.02	.94
Average, 1902 and 1905	......	22.37	29.38	14.93	14.18	.78	.91
2,000 POUNDS NORMAL FORMULA; 1 APPLICATION.							
1902	6	19.40	23.84	14.55	12.68	0.56	1.48
1903	4	11.95	16.00	11.10	9.20	1.39	1.74
1904	33	28.20	25.90	13.22	13.96	1.39	1.50
1905	4	19.30	22.65	14.32	....	.86	....
General average	......	19.71	22.10	13.30	11.95	1.05	1.48
Average, 1902 and 1905	......	19.35	23.25	14.44	12.68	.71	1.48
2,000 POUNDS NORMAL FORMULA; 2 APPLICATIONS.							
1902	7	24.60	39.40	15.21	14.25	0.52	0.98
1903	8	15.45	16.35	9.60	9.30	1.98	1.99
	29	15.60	15.35	10.50	10.50	1.63	1.60
1904	8	27.25	23.75	14.63	14.53	1.02	1.23
	29	29.25	23.40	13.77	13.95	1.27	1.13
1905	8	24.90	30.00	13.65	12.95	.97	.98
	29	26.80	25.50	13.97	14.79	.66	.81
General average	......	23.41	24.82	13.05	12.90	1.15	1.25
Average, 1902 and 1905	......	25.43	31.63	14.28	14.00	.72	.92
2,000 POUNDS NORMAL FORMULA; 3 APPLICATIONS.							
1902	8	24.60	28.88	15.18	13.34	0.54	1.25
1903	12	15.35	15.15	10.60	10.20	1.75	1.68
1904	12	28.60	24.55	14.02	13.13	1.10	1.49
1905	12	22.30	25.95	14.50	13.35	.76	1.01
General average	......	22.71	23.63	13.58	12.51	1.04	1.36
Average, 1902 and 1905	......	23.45	27.42	14.84	13.35	.65	1.13
1,200 POUNDS REVISED FORMULA; 1 APPLICATION.							
1904	13	25.20	17.80	15.21	14.17	0.91	1.25
1905	13	18.00	22.05	15.22	14.22	.58	.92
	45	20.35	20.00	12.74	....	1.16	.64
Average	......	21.18	19.95	14.39	14.20	.88	.94

TABLE VIII.—*Comparative statement of yield of cane lands with different fertilizers, and quality of cane produced, Cairo, Ga., 1902–1905*—Continued.

1,200 POUNDS REVISED FORMULA + 200 POUNDS NITRATE OF SODA LATER IN 1 APPLICATION.

Year.	Plat No.	Yield per acre.		Sucrose.		Reducing sugar.	
		Field A.	Field B.	Field A.	Field B.	Field A.	Field B.
		Tons.	*Tons.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1905	9	21.00	28.15	13.82	13.31	0.90	1.10
	46	22.50	23.50	14.55	13.74	.75	.78
Average	......	21.75	25.93	14.19	13.53	.83	.94

1,200 POUNDS REVISED FORMULA + 200 POUNDS NITRATE OF SODA LATER IN 2 APPLICATIONS.

1904	5	28.30	17.55	14.60	14.58	0.94	1.14
	24	28.15	20.05	14.02	12.45	.99	1.47
1905	5	17.80	22.30	15.00	15.95	.67	.92
	24	22.10	19.85	14.40	15.43	.92	.62
Average	......	24.09	19.94	14.51	14.10	.88	1.04

1,200 POUNDS REVISED FORMULA + 200 POUNDS NITRATE OF SODA LATER IN 3 APPLICATIONS.

1904	9	24.60	19.85	14.38	15.74	1.05	1.52

720 POUNDS ACID PHOSPHATE.

1903	14	7.10	4.65	....	9.00	....	1.40
	24	12.50	3.45	11.10	7.60	1.37	1.21
1904	14	20.20	11.75	13.78	13.35	1.27	1.23
1905	14	13.70	16.00	14.97	15.02	.56	.64
	50	13.15	14.00	13.36	15.08	.74	.58
Average	......	13.33	9.97	13.30	12.01	.99	1.01

120 POUNDS MURIATE OF POTASH.

1903	15	9.15	7.75	10.60	10.70	1.78	1.21
1904	15	20.20	6.50	14.10	12.92	1.24	1.33
1905	15	14.50	17.40	14.70	15.66	.60	.54
Average	......	14.62	10.55	13.13	13.09	1.21	1.03

490 POUNDS KAINIT.

1903	25	9.35	7.70	9.60	9.20	1.77	1.56
1904	25	17.10	10.45	15.37	13.42	.70	1.36
1905	25	11.25	10.75	13.12	13.68	1.01	1.01
Average	......	12.51	9.63	12.70	12.10	1.16	1.31

480 POUNDS COTTON-SEED MEAL.

1903	26	12.65	7.10	10.10	8.50	1.56	1.38
1904	26	16.10	10.20	14.36	12.87	.98	1.53
1905	26	16.00	16.85	14.54	14.61	.64	.74
Average	......	14.92	11.38	13.00	12.00	1.06	1.22

240 POUNDS NITRATE OF SODA.

1905	16	17.40	18.90	14.88	14.56	0.99	0.73

TABLE VIII.—*Comparative statement of yield of cane lands with different fertilizers, and quality of cane produced, Cairo, Ga., 1902–1905*—Continued.

720 POUNDS ACID PHOSPHATE+120 POUNDS MURIATE OF POTASH.

Year.	Plat No.	Yield per acre.		Sucrose.		Reducing sugar.	
		Field A.	Field B.	Field A.	Field B.	Field A.	Field B.
		Tons.	*Tons.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1902	13	10.80	24.40	16.41	14.52	0.37	0.92
1903	19	14.35	7.75	12.30	10.40	1.34	1.50
1904	19	26.15	11.40	14.34	13.97	1.19	1 03
1905	19	16.50	19.25	15.25	15.11	.64	.55
General average		16.90	15.70	14.58	13.50	.89	1.00
Average, 1902 and 1905		13.65	21.83	15.83	14.82	.51	.74

720 POUNDS ACID PHOSPHATE+240 POUNDS NITRATE OF SODA.

1903	18	12.70	6.50	12.20	9.60	1.43	1.36
1904	18	23.00	9.60	12.46	13.78	1.48	1.04
1905	18	17.30	21.45	14.90	14.53	.78	.69
Average		17.67	12.52	13.19	12.64	1.23	1.03

720 POUNDS ACID PHOSPHATE+480 POUNDS COTTON-SEED MEAL.

1903	22	8.50	5.75	10.70	8.20	1.50	1.49
1904	22	21.50	14.75	13.94	11.94	1.13	1.48
1905	22	15.50	16.85	14.16	15.67	.66	.47
Average		15.17	12.45	12.93	11.94	1.10	1.15

720 POUNDS ACID PHOSPHATE+480 POUNDS KAINIT.

1903	21	13.15	10.10	10.40	11.50	1.28	1.18
1904	21	23.70	15.85	13.63	14.36	1.21	1.23
1905	21	12.40	16.40	14.57	14.88	.81	.56
Average		16.42	14.12	12.87	13.58	1.10	.99

240 POUNDS NITRATE OF SODA+120 POUNDS MURIATE OF POTASH.

1903	20	9.85	8.20	11.70	10.60	1.67	1.32
1904	20	20.80	6.05	13.73	13.82	1.30	1.17
1905	20	15.10	20.30	13.33	13.54	....	1.08
	51	18.50	21.50	14.18	14.38	.75	.75
Average		16.06	14.01	13.24	13.09	1.24	1.08

1,440 POUNDS ACID PHOSPHATE+120 POUNDS MURIATE OF POTASH+240 POUNDS NITRATE OF SODA.

1903	39	12.85	15.45	10.50	11.20	1.45	1.24
1904	39	30.35	21.95	13.32	14.32	1.37	1.16
1905	39	26.90	21.40	13.35	14.45	1.05	.86
	52	20.70	23.15	13.26	15.00	.97	.62
Average		22.70	20.49	12.61	13.74	1.21	.97

720 POUNDS ACID PHOSPHATE+240 POUNDS MURIATE OF POTASH+240 POUNDS NITRATE OF SODA.

1903	40	11.05	14.20	10.40	10.60	1.86	1.38
1904	40	28.95	25.00	13.61	15.36	1.33	1.10
1905	40	19.50	19.45	12.95	13.96	1.18	.98
Average		19.83	19.55	12.32	13.31	1.46	1.15

TABLE VIII.—*Comparative statement of yield of cane lands with different fertilizers, and quality of cane produced, Cairo, Ga., 1902–1905*—Continued.

720 POUNDS ACID PHOSPHATE+120 POUNDS MURIATE OF POTASH+480 POUNDS NITRATE OF SODA.

Year.	Plat No.	Yield per acre.		Sucrose.		Reducing sugar.	
		Field A.	Field B.	Field A.	Field B.	Field A.	Field B.
		Tons.	*Tons.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1903	41	12.75	13.15	10.70	9.90	1.73	1.93
1904	41	24.75	16.25	13.33	15.18	1.39	1.00
1905	41	19.50	17.80	13.26	14.56	1.04	.77
Average	......	19.00	15.73	12.43	13.21	1.39	1.23

24 BUSHELS COTTON SEED+720 POUNDS ACID PHOSPHATE+120 POUNDS MURIATE OF POTASH.

1903	37	10.55	13.20	10.84	10.50	1.48	1.37
1904	37	25.30	21.85	13.92	13.81	1.10	1.17
1905	37	20.65	19.80	14.16	14.96	.91	.57
Average	......	18.83	15.95	12.97	13.09	1.16	1.04

57 BUSHELS COTTON SEED+720 POUNDS ACID PHOSPHATE+120 POUNDS MURIATE OF POTASH.

1903	38	13 90	16.35	11.00	10.80	1.43	1.47
1904	38	26.75	24.25	13.60	13.86	1.34	1.21
1905	38	24.95	21.45	13.66	13.07	.92	.99
Average	......	21.87	20.86	12.75	12.58	1.23	1.22

30 BUSHELS COTTON SEED+1,000 POUNDS ACID PHOSPHATE+120 POUNDS MURIATE OF POTASH+100 POUNDS NITRATE OF SODA.

1905	56	21.75	17.50	13.95	14.79	0.76	0.75
	61	21.25	22.00	13.77	14.72	.94	.78
Average	......	21.50	19.75	13.86	14.76	.85	.97

30 BUSHELS COTTON-SEED+1,000 POUNDS ACID PHOSPHATE+120 POUNDS MURIATE OF POTASH+100 POUNDS NITRATE OF SODA+100 POUNDS NITRATE OF SODA IN JULY.

1905	57	18.80	23.45	13.41	15.18	0.97	0.55
	62	21.05	22.25	12.48	14.88	1.29	.72
Average	......	19.93	22.85	12.95	14.99	1.13	.64

180 POUNDS ACID PHOSPHATE+120 POUNDS MURIATE OF POTASH+240 POUNDS NITRATE OF SODA.

1905	53	21.05	16.55	13.98	14.34	0.90	0.80
	58	16.50	18.10	14.22	13.34	.83	.99
Average	......	18.78	17.28	14.10	13.84	.87	.90

360 POUNDS ACID PHOSPHATE+120 POUNDS MURIATE OF POTASH+240 POUNDS NITRATE OF SODA.

1905	54	18.85	16.90	13.88	13.11	0.84	0.90
	59	16.50	19.75	13.64	13.17	.98	1.15
Average	......	17.68	18.32	13.76	13.14	.91	1.03

TABLE VIII.—*Comparative statement of yield of cane lands with different fertilizers, and quality of cane produced, Cairo, Ga., 1902–1905*—Continued.

Year.	Plat No.	Yield per acre.		Sucrose.		Reducing sugar.	
		Field A.	Field B.	Field A.	Field B.	Field A.	Field B.
1,080 POUNDS ACID PHOSPHATE+120 POUNDS MURIATE OF POTASH+240 POUNDS NITRATE OF SODA.							
		Tons.	*Tons.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1905	55	19.75	19.75	13.07	14.50	1.15	0.81
	60	17.00	23.25	13.08	14.77	.89	.59
Average	......	18.38	21.50	13.08	14.64	1.02	.70
650 POUNDS ACID PHOSPHATE+1,720 POUNDS COTTON SEED+97 POUNDS MURIATE OF POTASH.							
1902	21	19.08	31.62	16.28	14.55	0.39	0.83
720 POUNDS ACID PHOSPHATE+240 POUNDS COTTON-SEED MEAL+120 POUNDS NITRATE OF SODA+480 POUNDS KAINIT.							
1902	22	19.00	26.60	16.12	13.26	0.44	1.25
720 POUNDS ACID PHOSPHATE+240 POUNDS COTTON-SEED MEAL+120 POUNDS NITRATE OF SODA+120 POUNDS MURIATE OF POTASH.							
1902	23	19.32	26.60	16.20	14.28	0.44	0.94
720 POUNDS ACID PHOSPHATE+240 POUNDS COTTON-SEED MEAL+120 POUNDS NITRATE OF SODA.							
1902	12	13.56	19.76	15.27	14.74	0.55	0.91
240 POUNDS COTTON-SEED MEAL+120 POUNDS NITRATE OF SODA+120 POUNDS MURIATE OF POTASH.							
1902	14	14.72	18.80	16.25	14.79	0.33	1.18
1,440 POUNDS ACID PHOSPHATE+240 POUNDS COTTON-SEED MEAL+120 POUNDS NITRATE OF SODA+120 POUNDS MURIATE OF POTASH.							
1902	15	18.24	31.50	16.01	14.01	0.46	0.91
720 POUNDS ACID PHOSPHATE+480 POUNDS COTTON-SEED MEAL+240 POUNDS NITRATE OF SODA+120 POUNDS MURIATE OF POTASH.							
1902	16	23.44	24.50	14.93	13.01	0.64	1.52
720 POUNDS ACID PHOSPHATE+240 POUNDS COTTON-SEED MEAL+120 POUNDS NITRATE OF SODA+240 POUNDS MURIATE OF POTASH.							
1902	17	19.84	25.60	16.31	12.66	0.39	1.29
675 POUNDS ACID PHOSPHATE+525 POUNDS COTTON-SEED MEAL+110 POUNDS MURIATE OF POTASH.							
1902	18	17.32	29.00	16.22	15.05	0.40	0.80

TABLE VIII.—*Comparative statement of yield of cane lands with different fertilizers, and quality of cane produced, Cairo, Ga., 1902–1905*—Continued.

Year.	Plat No.	Yield per acre.		Sucrose.		Reducing sugar.	
		Field A.	Field B.	Field A.	Field B.	Field A.	Field B.
756 POUNDS ACID PHOSPHATE+221 POUNDS NITRATE OF SODA+126 POUNDS MURIATE OF POTASH.							
		Tons.	*Tons.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1902	19	20.36	29.08	15.56	14.77	0.49	0.91
720 POUNDS ACID PHOSPHATE+728 POUNDS COTTON SEED+120 POUNDS MURIATE OF POTASH.							
1902	20	13.80	26.30	16.22	14.52	0.42	0.86
1.200 POUNDS LOW-GRADE FERTILIZER.							
1902	11	15.04	24.08	15.63	14.23	0.40	1.00
800 POUNDS PERUVIAN GUANO; 2 APPLICATIONS.							
1904	43	....	13.50	....	14.92	....	1.32
	45	....	14.10	....	14.48	....	1.03
Average		....	13.80	....	14.71	....	1.18
1,200 POUNDS PERUVIAN GUANO.							
1904	44	....	17.55	....	15.00	....	0.90
	46	....	15.60	....	15.02	....	.84
Average		....	16.58	....	15.01	....	.87

DISCUSSION AND COMPARISON OF THE DATA.

EXPERIMENTS WITH NO FERTILIZER.

The yields and composition of the cane on the plats to which no fertilizer was applied are considered first. The data show that the average yield on field A for the four years on the unfertilized plats is 9.53 tons and on field B 7.01 tons per acre. The average percentage of sucrose in the juice of the canes from field A is 11.88 and from field B 11.03. The average percentage of reducing sugar on field A is 1.23 and on field B 1.26 per cent. Comparing fields A and B for 1902 and 1905, in which the same plats of land were used, it is seen that the average yield on field A is 10.75 tons per acre and on field B 14.10 tons per acre. The superior natural fertility of field B has therefore produced an increased yield of 3.35 tons per acre. In respect to the composition of the juices of the canes in the two fields it is seen that on field B there is a slightly increased percentage of sugar and also a slightly increased percentage of reducing sugar. The above data show that for the average tillable land of that part of Georgia over the series of four years the average yield of cane without fertilizer is about 8 tons per acre. It is important, however, to note the seasonal influences. The yield for 1903 is a remarkably poor one both in quantity of cane and in quality. As these poor seasons, however, regularly recur, it is not probable that the general average was unduly influenced by including the results for 1903. The following season, 1904, was a remarkably good one as regards both yield and quality. In that season field A was a new land and field B an old land.

EXPERIMENTS WITH THE NORMAL-FORMULA FERTILIZER.

Having studied the yields which can be obtained without the use of fertilizers, the next important problem is the study of the effects of different kinds of fertilizers, different quantities of fertilizers, and different methods of distribution upon the yield and composition of the cane. The so-called normal-formula fertilizer used during the experimental work was a mixture of various fertilizing ingredients containing 9.03 per cent of available phosphoric acid, 5.15 per cent of potash, and 3.90 per cent of nitrogen, reckoned as ammonia. In 1903 800 pounds of this fertilizer were sown broadcast, resulting in an increase over the average for the unfertilized plat A of 2.33 tons per acre, and on field B 0.94 of a ton. Comparing the results with the average for 1902 and 1905 only, gains of 3.55 and 6.15 tons per acre on fields A and B, respectively, are shown on the fertilized plats.

The same quantity of normal fertilizer was applied in one, two, and three applications made before planting and at intervals afterwards during the growth of the crop. The data show for the whole series of experiments that 800 pounds of normal-formula fertilizer applied at one time, before planting, produced an average yield of 18.07 tons on field A, and 17.56 tons on field B, producing canes which contained 14.04 per cent of sucrose on field A and 13.83 per cent on field B, with 0.87 per cent and 1.01 per cent, respectively, of reducing sugar. Considering the average for fields A and B for 1902 and 1905, the yields per acre are 16.44 tons and 20.40 tons, respectively, showing an increase on field B over field A of 3.96 tons per acre. This, of course, was due to the superior fertility of field B, as it is almost exactly the same difference as was found on the plats where no fertilizer was used. In this case, therefore, it is seen that the 800 pounds of fertilizer made up according to the normal formula did not change the relative fertility of the two fields, but only increased the yield. The increase over the unfertilized plats is 8.54 tons per acre on field A for the whole number of years and 10.55 tons per acre on field B.

When the 800 pounds of this fertilizer was added, partly before planting and partly at a later period of growth, as described in the reports, the average yield on field A was 18.64 tons per acre and on field B 17.03 tons per acre. These data show that there was practically no benefit, taken as a whole, from dividing the fertilizer into two portions and applying one at the time of planting and one during the period of growth. If, however, the comparison is made upon fields A and B for 1902 and 1905, respectively, being identical pieces of land, it appears that a great benefit was secured by dividing the fertilizer, amounting on field A to 3.29 tons per acre and on field B to 2.24 tons per acre. When 800 pounds of normal-formula fertilizer were used in three applications, one before planting and the other two at successive periods of growth, the yield per acre on field A was 15.62 tons and on field B 16.50 tons. No application of this kind was made in the first year of the experiment, and therefore no comparison can be made with the whole series. Apparently the yields per acre—namely, 15.62 tons and 16.50 tons, respectively—are not so great as in the case of a single application, especially in the case of field A. It is noticed, however, that the experiment was made only with one plat in each case, and therefore is not conclusive, as the variations between plats in the same year was sometimes greater than the variations in the whole field from year to year.

The effect of increasing the quantity of fertilizer applied is next considered. The first comparison is in the case of the use of 1,200 pounds of the normal fertilizer broadcasted. It should be understood in this sense that wherever the terms "one application," "two applications," etc., are used it means the use of the fertilizer in or near the row in contrast with the term "broadcast." For three years there is is a comparison of the plats on which 1,200 pounds of normal formula was thrown broadcast in which the average yield per acre is 16.97 tons and 18.48 tons, respectively. In this case the cane in field B is considerably richer in sucrose, while there is but little difference in the content of reducing sugar.

Comparing the plats for 1902 and 1905, the yields are 18.59 tons and 21.63 tons, respectively; and again the cane grown on field B contains a larger quantity of sucrose, but a very much smaller quantity of reducing sugar. In fact, its composition would have made it exceptionally valuable for the manufacture of sugar.

These average data can not be compared with the results from sowing 800 pounds of the same fertilizer broadcast, because that was done in only one year. We may, however, compare the data for that year. In field A when 800 pounds were used the yield was 7.20 tons per acre in 1903, while it was 12.10 tons per acre where 1,200 pounds were used—an increase of 4.90 tons. In field B the yield with 800 pounds of fertilizer was 7.95 tons per acre, while it was 9.05 tons with 1,200 pounds—an increase of 1.10 tons per acre.

Where 1,200 pounds of the normal fertilizer was used in one application before planting the average yield for field A for the four years is 21.07 tons per acre and for field B 19.73 tons per acre. Again field

B shows a higher content of sucrose in the juices. Comparing these data with those for the use of 800 pounds of fertilizer in one application it is seen that in field A there is an increased yield of 3 tons per acre and in field B of 2.17 tons per acre; and for 1902 and 1905, being the same fields, there is an increased yield in field A of 2.10 tons per acre and in field B of 0.94 ton per acre. Combining the increased yields into one expression we find an average increased yield of 2.05 tons per acre, as a compensation for the excess of 400 pounds of fertilizer used. Assuming that the cane is worth $3 per ton, we find the increased yield in money is $6.15. Assuming that the fertilizer is worth $12 per ton, the increased cost of the fertilizer is $2.40, leaving a balance of profit of $3.75 per acre in favor of using the additional 400 pounds.

In the use of 1,200 pounds of the normal-formula fertilizer in two applications, one previous to planting and one later, it is seen that the average yield for field A is 19.53 tons and for field B 19.15 tons per acre.

The cane from field B shows a slightly greater quantity of sucrose in the juices and a slightly decreased amount of reducing sugar. For the years 1902 and 1905, with the same pieces of land, the average yield for field A is 19.57 tons and for field B 22.35 tons per acre, the quality of the cane in field B being somewhat better than in field A. In comparing the yields produced by 1,200 pounds of the normal-formula fertilizer in two applications with those produced by a single application the following results are obtained: In field A there is a loss of 1.54 tons per acre as a result of two applications; in field B there is a loss of 0.58 ton per acre. Comparing fields A and B for 1902 and 1905 there is a gain in favor of two applications of 1.03 tons per acre in field A and of 1.01 tons per acre in field B. The results, therefore, are not decisive, showing a loss upon the whole for the four years by the two applications, but a gain in the years 1902 and 1905 as compared with the result of one application.

Attention will next be given to the results of using 1,200 pounds of the normal-formula fertilizer in three applications, one at the time of planting and two at successive periods of growth. The average yield for the four years in field A for three applications is 18.60 tons and for field B 20.08 tons per acre, field A showing a slightly better quality of juice. Comparing these figures with the results for two applications of the same fertilizer, it is seen that there is a loss of 0.93 ton per acre in field A and a gain of 0.93 ton per acre in field B. These data indicate that no advantage results from the splitting up of the fertilizer into three portions to be applied at different times. In the years 1902 and 1905 the average yield on field A from three applications is 19.70 tons per acre and on field B 24.23 tons per acre. Compared with similar data for two applications there is a gain of 0.13 ton per acre on field A and a gain of 1.88 tons per acre on field B, field B in this case showing a greater gain than field A. These data show a slight tendency to increase of yield as a result of three applications.

As a general conclusion it may be said that the results of dividing the fertilizer and making two or three applications, as compared with the results of applying it all at one time, do not show a sufficient advantage to justify the extra expense involved.

The next comparison relates to increasing the quantity of the normal-formula fertilizer to 2,000 pounds per acre. The fertilizer was not sown broadcast in 1904, but for the other three years the average yield on field A from 2,000 pounds of fertilizer is 19.90 tons per acre and on field B 23.12 tons per acre, with practically no difference in the character of the cane produced. It is possible to make a direct comparison with fields A and B for 1902 and 1905. The average yield from 2,000 pounds broadcasted in field A for the two years is 22.37 tons and in field B 29.38 tons. This is an increase over the tonnage produced with 1,200 pounds per acre applied broadcast, of 3.78 tons on field A and 7.75 tons per acre on field B. With 2,000 pounds put on in a single application, the average yield on field A is 19.71 tons and on field B 22.10 tons per acre. These results compared with the results from using 1,200 pounds in one application show a loss in yield of 1.36 tons in field A and a gain of 2.37 tons in field B. For the years 1902 and 1905 the yield in the case of 2,000 pounds in one application in field A is 19.35 tons and in field B 23.25 tons per acre. Compared with the use of 1,200 pounds in one application, this shows a gain of 0.81 ton per acre in field A and a gain of 1.91 tons per acre in field B. In this case the data are somewhat conflicting, but upon the whole show a very slight increase due to the use of the increased quantity of fertilizer. This increased yield, however, is hardly sufficient to justify the additional expense of the additional 800 pounds of fertilizer.

In the case of two applications of 2,000 pounds, half at the time of planting and half at a subsequent period of growth, the yield for field A is 23.41 tons and for field B 24.82 tons per acre. Compared with the use of 1,200 pounds in two applications, this shows an increase in field A of 3.88 tons per acre and on field B of 5.67 tons per acre. For 1902 and 1905, for fields A and B, the yields by the use of 2,000 pounds in two applications are 25.43 and 31.63 tons, respectively. This shows, when compared with the application of 1,200 pounds in two applications, an increase of 5.86 tons in field A and 9.28 tons per acre in field B. Compared with the yield secured by the use of 2,000 pounds of normal fertilizer in one application, for the four years, there is an increase of 3.70 tons in field A and 2.72 tons in field B in favor of the two applications. For 1902 and 1905 there is an increase of 6.08 tons per acre in field A and 8.38 tons per acre in field B. These data show a very large increase in yield due to the application of the fertilizer at successive periods.

Attention will next be directed to the application of 2,000 pounds of fertilizer per acre at three different times. The average yield on field A for the four years, with 2,000 pounds of fertilizer per acre in three applications, is 22.71 tons and for field B 23.63 tons, which, compared with two applications, indicates a loss of 0.70 ton per acre on field A and 1.19 tons per acre on field B. For 1902 and 1905 there is indicated a loss of 1.98 tons per acre on field A and 4.21 tons per acre on field B. These data would seem to indicate a loss in efficiency of the fertilizer when applied at three successive intervals instead of at two.

EXPERIMENTS WITH THE REVISED-FORMULA FERTILIZER.

The next experiment to be considered is that with 1,200 pounds of revised-formula fertilizer for the years 1904 and 1905. The average for these two years on field A is 21.18 tons per acre and on field B 19.95 tons per acre. There is little difference in the character of the canes produced on the two fields. When the 1,200 pounds of the revised-formula fertilizer was used with an addition of 200 pounds of sodium nitrate, the yield in 1905 was 21.75 tons per acre on field A and 25.93 tons per acre on field B. A comparison of these figures with the tonnage obtained in 1905, when 1,200 pounds of the revised formula alone were used, shows a considerable increase in the yield of field A (2.57 tons) and a very large increase in the yield of field B (4.90 tons). The increase in the yield of field B, however, was at the expense of the character of the juice, which is less rich in sugar than when no sodium nitrate was employed.

Where 200 pounds of sodium nitrate was used in two applications, after the application of 1,200 pounds of the revised formula, the comparisons can be made directly with the revised formula in one application for the two years, 1904 and 1905. The average yield on field A is 24.09 tons per acre and on field B 19.94 tons per acre, with but little difference in the character of the juice. In this instance it is seen that a considerable increase in the yield of field A is obtained and no increase in the yield of field B.

In the next case 1,200 pounds of the revised formula was used, with the addition of 200 pounds of sodium nitrate used later in three different applications. In this case, comparing the yields for 1904 only, there is a loss in field A of 0.6 of a ton when the sodium nitrate was used, and a gain of 2.05 tons in field B. These data are somewhat conflicting and would seem to be indicate that there is no marked or continued gain in yield by the addition of 200 pounds of sodium nitrate to the 1,200 pounds of revised-formula fertilizer. In four instances gains were shown and in two instances there were slight losses. It does not seem advisable, therefore, to recommend the addition of this quantity of sodium nitrate, either to be used in one application with the 1,200 pounds of the revised formula or at intervals.

EXPERIMENTS WITH VARIOUS COMBINATIONS OF FERTILIZERS.

The effect of the application of acid phosphate alone at the rate of 720 pounds per acre will be considered next. The data show the yield of 13.33 tons per acre on field A and 9.97 tons per acre on field B. This shows an increase of yield per acre over that obtained on the blank plats (excluding the year 1902) of between 3 and 4 tons on both fields.

The effect of potash alone is shown in the next comparison, excluding the year 1902. The data show a yield of 14.62 tons per acre on field A and 10.55 tons per acre on field B. The addition of 120 pounds of potash, therefore, produces a larger yield in this soil than 720 pounds of acid phosphate. The potash used was in the form of potassium chlorid. An equivalent amount of potash used in the form of kainit—namely, at the rate of 490 pounds per acre—did not produce such large results, the average being on field A 12.51 tons per acre and on field B 9.63 tons per acre. There is, however, quite an increase over the unfertilized plats.

The effect of cotton-seed meal alone was also tested for all the years except 1902. The average yield per acre with the use of 480 pounds of cotton-seed meal on field A is 14.92 tons and on field B 11.38 tons. The principal fertilizing agent of cotton-seed meal is nitrogen, although it contains considerable quantities both of potash and phosphoric acid. The data show quite a large increase in yield over the blank plats—about 5 tons in each field.

Sodium nitrate was used alone only one year, namely, 1905, and the yield obtained on the single plat observed was 17.40 tons per acre on field A and 18.90 tons per acre on field B. This is about 6 tons greater than the yield of the blank plats in field A in that year, and over 4 tons greater than the yield in field B. By reason of its being tried, however, on a single plat, the data are not so convincing as those that were derived from a larger number of observations.

Experimental determinations were also made of the effect of mixing two fertilizers only. The first test was with a mixture of 720 pounds of acid phosphate and 120 pounds of potassium chlorid per acre. For the four years the average yield per acre on field A with this application was 16.90 tons and on field B 15.70 tons per acre, being practically double that obtained without fertilization. The cane grown on field A was 1 per cent richer in sucrose than that growing on field B. For the years 1902 and 1905, where the experiments were made upon the same kind of land, the average yield on field A was 13.65 tons per acre and on field B 21.83 tons per acre. The natural fertility of field B apparently caused the fertilizer to produce a larger effect than when applied to field A, which was poor land. The average percentage of sucrose was again 1 per cent greater in field A than in field B.

A test was made with a mixture of 720 pounds of acid phosphate and 240 pounds of sodium nitrate. The comparison is made on a yield of three years. For field A the average was 17.67 tons per acre and for field B 12.52 tons per acre. The cane grown on field A was one-half per cent richer in sucrose than that grown on field B. The yield on field A was greater and the yield on field B less than in the case where acid phosphate and potassium chlorid were used.

A like comparison was made with 720 pounds of acid phosphate and 480 pounds of cotton-seed meal. The average for the three years on field A was 15.17 tons per acre and on field B 12.45 tons per acre. The percentage of sucrose in the canes of field A was 1 per cent greater than on field B. These data show no very striking difference between the action of cotton-seed meal and sodium nitrate.

The use of 720 pounds of acid phosphate and 480 pounds of kainit resulted in a slightly greater tonnage than in the case of cotton-seed meal—i. e., 16.42 tons and 14.12 tons on fields A and B, respectively. The content of sucrose obtained from field B was higher.

A comparison was also made with a mixture of sodium nitrate and potassium chlorid without any addition of acid phosphate. The average yield on field A was 16.06 tons per acre and on field B 14.01 tons per acre. These data show that the use of 720 pounds of acid phosphate in connection with the other fertilizers produced no greater yield than the use of a mixture of sodium nitrate and potassium chlorid alone. There is a marked difference, however, when a very large quantity of acid phosphate is used in connection with potassium chlorid and sodium nitrate. In this case it is seen that the average yield on field A was 22.70 tons per acre and on field B 20.49 tons per acre. The average percentage of sucrose in field B is more than 1 per cent greater than in field A. When the acid phosphate in the application was reduced by one-half, and the potassium chlorid was doubled, as in the next comparison, the average yield on field A was 19.83 tons per acre and on field B 19.55 tons per acre. Again the percentage of sucrose in field B was 1 per cent greater than in field A.

These data show that the increase of the acid phosphate to 1,440 pounds per acre gave 2.87 tons more per acre in field A and 0.94 ton per acre more in field B. When the quantity of potassium chlorid used in the last experiment was diminished by one-half and the quantity of sodium nitrate doubled the yields were as follows: On field A 19 tons per acre and on field B 15.73 tons per acre. The sucrose in field B was three-fourths per cent greater than in field A. The change in the relative quantities of the potash and nitrate of soda did not in this case produce any favorable effect, but rather caused a falling off of almost 4 tons per acre in the yield of field B.

When the nitrogen was supplied in the form of 24 bushels of cotton seed per acre with 720 pounds of acid phosphate and 120 pounds of muriate of potash, the yield on field A was 18.83 tons per acre for the three years, and on field B 15.95 tons per acre. The cotton seed did not appear to produce quite as good an effect as the nitrate of soda.

When the quantity of cotton seed was raised to 57 bushels per acre—more than doubled—the other constituents remaining the same, the yield on field A for the three years was 21.87 tons per acre and on field B 20.86 tons per acre. The increase in the quantity of cotton seed applied thus produced a marked increase in yield.

In another experiment the quantity of cotton seed was reduced to 30 bushels per acre and the quantity of acid phosphate raised to 1,000 pounds per acre, the quantity of potassium chlorid remaining the same, and 100 pounds of sodium nitrate being added to the ration. Only one year's test of this combination was made, giving a yield of 21.50 tons per acre on field A and 19.75 tons on field B. The sugar in the canes of field B was almost 1 per cent greater than in the canes of field A. This variation in the fertilizer did not increase the yield.

In still another experiment the same fertilizers were used, but double the amount of nitrate of soda was applied, one-half at the time of planting and the other in July. The yield on field A, namely, 19.93 tons per acre, is less than in the preceding experiment, and on field B the yield of 22.85 tons shows an increase. It can not be argued, therefore, that the application of the double amount of sodium nitrate in two portions is of any practical value.

The quantity of acid phosphate was reduced to 180 pounds and the quantity of sodium nitrate increased to 240 pounds, applied all at once, in the experimental work for 1905. The resulting yield was 18.78 tons on field A and 17.28 tons on field B. Diminishing the phosphoric acid to such an extent causes a loss which is not wholly overcome by doubling the amount of sodium nitrate.

When the amount of acid phosphate was doubled, the yield was decreased about 1 ton on field A and increased about 1 ton on field B per acre, showing no marked effect either way.

The other data tabulated for single years can be sufficiently interpreted by mere inspection and do not need any further elucidation.

SUMMARY.

In summarizing these data reference should again be made to the analyses of the soils themselves. Analyses of the two fields used at Cairo in Mr. Roddenbery's experiments, and also a general review of the character of the soils collected from different parts of the State where sugar cane is grown, have been published in previous reports.[a] The average composition of the soil and subsoil of the experimental plats of 1904 is shown in the following table:[b]

TABLE IX.—*Average analyses of soil from fields A and B, experimental plats, Cairo, Ga., 1904.*

Description.	Insoluble matter (by difference).	Volatile matter.	Alumina and iron.	Calcium.	Magnesium.	Potash.	Phosphoric acid.	Nitrogen.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Field A	89.74	3.50	6.53	0.03	0.027	0.13	0.015	0.039
Field B	91.62	2.96	5.19	.02	.027	.14	.010	.039
Average	90.68	3.23	5.86	.025	.027	.135	.125	.039

It appears that these soils are even poorer than the average south Georgia soils, for, according to the data given in Bulletin No. 70,[c] 65 samples of soil examined contained on an average 92.24 per cent of insoluble matter; 12 samples contained an average of 0.173 per cent of potash, the remainder carrying only traces; 53 samples averaged 0.058 per cent of phosphoric acid, and the 65 samples carried an average of 0.058 per cent of nitrogen.

These data show that the soils on which the sugar canes are grown in Georgia are essentially silicious. They contain altogether, including combined moisture in the air-dry state, less than 10 per cent of materials not sand. The elements commonly known as essential plant foods, namely, potash, phosphoric acid, and nitrogen, are present in extremely small quantities; and in large numbers of the soils of the State the potash appears only as a trace, being evidently the least abundant of the necessary elements. It is fortunate that in a soil of this kind its sandy nature prevents its becoming packed, and therefore there is less opposition to the spread of the root systems than in a heavy compact soil. The plant, therefore, can gather quantities of food from the exceedingly small stores present. Nevertheless, it is evident that, for remunerative agriculture, soils of this kind must be fed, and well fed, each year. The modern methods of farming, including the cultivation of green crops for manuring purposes, will do much to improve this soil and increase its content of humus which may serve to hold or store plant foods for future use. Especially is this true of nitrogen which may be grown in green, leguminous

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[a] Bul. No. 70, p. 11; Bul. No. 93, p. 40.

[b] Bul. No. 93, p. 42.

[c] Pages 16–18.

crops, and thus added to the soils in perhaps a less expensive way than by its purchase at present market prices. There is no way, however, of increasing the other plant foods of the soil except by artificial additions, and it is not to be expected that profitable agriculture can be conducted with soils of this character without a generous though judicious and scientific application of fertilizers.

It is easy to see from the analytical data the reason for the use of the so-called complete fertilizer, that is, a fertilizer which contains all of the principal essential elements of plant food, namely, potash, phosphoric acid, and nitrogen. The combination of plant foods represented by the normal formula or the revised formula seems to work very well on these soils and no great advantage has been shown in the experimental work in departing very widely from the quantities of materials used in this formula. More extended experimental work is necessary, however, over a larger number of soils before any definite rules respecting the variations from this normal basis can be formulated.

In general, it may be said that the addition to the soil of the quantities of plant food contained in the normal-formula fertilizer may be considered necessary for the production of profitable crops of sugar cane. By the growing of winter crops and other catch crops and by more perfect systems of cultivation and rotation, the maximum benefits to be derived from the complete fertilizer will be secured and the minimum waste through drainage be suffered.

From the average results of the experiments it may be said with reasonable certainty that the magnitude of the crop of sugar cane may be about doubled by the application of an amount of plant food per acre represented by the normal formula which has been used. (See page 7.)

GENERAL CONCLUSIONS.

The experimental work connected with the development of table-sirup manufacture from sugar cane is now finished. The various problems which have arisen in connection with this industry have been solved. The methods of fertilization best suited for the production of a maximum crop at a minimum cost have been elucidated. The way has been pointed out in which the finished sirup may be kept from fermentation during the summer season, either by sterilization in cans or by placing it in sterilized barrels. It has been shown that there is no necessity in the manufacture of table sirup directly from sugar cane to use any kind of a chemical reagent for clarifying, bleaching, or preserving the finished product. It has been demonstrated that a highly palatable product can be made, having a pleasing color and a reasonable degree of clearness, by the use of heat and mechanical skimming of the coagulated products. A method has been devised by means of which in a simple and rapid way every package of the finished sirup may be graded to a standard color. There is still a prejudice in the minds of many consumers in favor of the light-colored sirups. That this prejudice does not rest upon just grounds is readily seen, since by the admixture of glucose, which is a colorless substance, with the sirup a lighter-colored product is secured. In addition to this, by the use of fumes of burning sulphur upon the expressed juices, a much lighter-colored product is secured, but at the expense of incorporating an objectionable substance, namely, sulphuric acid, in the finished product. Thus a very light-colored sirup should awaken a suspicion of adulteration in the minds of the consumer instead of being regarded as an index of superiority. It is believed that the public taste could be easily educated in this regard to prefer the normal-colored products to those that are bleached, either chemically or by the addition of a colorless substance. The palatability of the unbleached finished product is without question superior; and the desirability of extending its consumption so that it may displace the mixed and adulterated articles should be apparent to all.

The agricultural industries of the Southern States, where sugar cane can be grown for the purpose mentioned, would be greatly benefited by an expansion of the market for this product commensurate with its palatability and nutritive properties. At the present time the market value is dangerously near the actual cost of production. Thus there is either no profit at all to the farmer and factory or else so slight a profit as to restrict unduly the expansion of the industry. A wider market would insure a reasonable increase of profits, and thus stimulate the agricultural and manufacturing industry connected with the production of table sirup from this source.

The sirup made directly from the sugar cane must of necessity commend itself to the consumer as preferable to molasses arising as a by-product of sugar manufacture. In the production of sugar it is an economical necessity to make a white product, and this requires the use of bleaching agents of some description. Among these sulphur is perhaps the most common. Also in the washing of white sugar in the centrifugal, solutions of salts of tin or of indigo are often employed to give an additional luster to the sugar. This bleaching agent must of necessity remain in the molasses, making it, to this extent, unsuitable for consumption. For these reasons it is evident that the production of a table sirup directly from the original source should be encouraged.

The three principal sources of table sirup at the present time available are the maple tree, the sorghum plant, and the sugar cane. It is true that some very good sirup has been made from the sugar beet, but the presence of large quantities of salts in the sugar beet is apt to render a sirup made therefrom less palatable and less wholesome than one made from either of the three sources first mentioned.

It may be asked if this supply of table sirups should be made wholly from original sources, what use could be made of molasses arising as a by-product in the manufacture of sugar? The answer to this question is a simple one. There are many economical applications of molasses aside from its use upon the table. Molasses when mixed properly with an absorbent makes an excellent cattle food. Molasses also when subjected to fermentation yields alcohol in paying quantities. The use of denaturized alcohol in the arts and industries free of tax makes possible the remunerative utilization of molasses for the manufacture of industrial alcohol. It appears from a general survey of the data which have been collected in these experiments that it is entirely possible to supply the demands for table sirups in the United States directly from the original sources, thus removing the danger of adulteration or contamination with substances injurious to health. The general consumption of a sirup of this kind would, it is true, interfere with those who are engaged at the present time in making a synthetic sirup for table use from doubtful sources, but which as a rule contains more or less molasses—the by-product of sugar manufacture—and contaminated to a greater or less degree with substances injurious to health. The welfare of the farmer and consumer would therefore be promoted by the general consumption of pure sirups of the kind described in this report.

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